

**PCT**WORLD INTELLECTUAL PROPERTY ORGANIZATION  
International Bureau

## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>7</sup> : <b>C08K 3/34, 9/04</b>	<b>A1</b>	(11) International Publication Number: <b>WO 00/66657</b> (43) International Publication Date: 9 November 2000 (09.11.00)
<p>(21) International Application Number: PCT/GB00/01652</p> <p>(22) International Filing Date: 28 April 2000 (28.04.00)</p> <p>(30) Priority Data: 99303444.6 30 April 1999 (30.04.99) EP</p> <p>(71) Applicant (for all designated States except US): ALCAN INTERNATIONAL LIMITED [CA/CA]; 1188 Sherbrooke Street West, Montreal, Quebec H3A 3G2 (CA).</p> <p>(72) Inventors; and (75) Inventors/Applicants (for US only): BROWN, Stephen, Clifford [GB/GB]; 37 Thompson Drive, Caversfield, Bicester, Oxfordshire OX6 9FA (GB). DAVID, Marie-Laure [FR/FR]; Résidence Les Amandiers, Appartement 75, 17, rue Winston Churchill, F-60200 Compiègne (FR). EVANS, Kenneth, Arthur [GB/GB]; Westward View, 4 Hillford Road, Chalfont St. Peter, Buckinghamshire SL9 0DX (GB). GARCIA, Javier, Prieto [ES/GB]; 47 Coopers Gate, Banbury, Oxfordshire OX16 2EQ (GB).</p> <p>(74) Agent: EASTWOOD, Simon, Christopher, Stevens, Hewlett &amp; Perkins, 1 St. Augustine's Place, Bristol BS1 4UD (GB).</p>		<p>(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</p> <p>Published With international search report.</p>
<p>(54) Title: FIRE RETARDANT COMPOSITIONS</p> <p>(57) Abstract</p> <p>A polymer composition is provided that comprises a polymer and a synergistic flame retardant additive combination which comprises a nano-clay and a second filler. The second filler may be a material with known flame retardant properties, an inert filler or a combination of the same. The preferred nano-clay is Cloisite, the preferred second filler is aluminium trihydroxide. The presence of this flame retardant additive combination in polymers increases the strength of the char that forms during combustion. The formation of a strong char creates a barrier to ignition of the underlying material, for example electrical cables that have been provided with a coating of the polymeric composition.</p>		

BEST AVAILABLE COPY

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

WO 00/66657

PCT/GB00/01652

### FIRE RETARDANT COMPOSITIONS

This invention relates to fire retardant or flame retardant (these terms being synonymous for present purposes) additives for polymeric materials.

5 More particularly, it relates to such additive compositions which have the effect of increasing the strength of the char formed when plastics burn.

The combustion of a polymer leads to the formation of a carbonaceous residue, ash or char. Many fire tests, such as the single burning item (SBI), UL94 and 3m-cube test (IEC1034 - also mentioned in other standards, for  
10 example BS 6724:1990 appendix F), have shown the importance of the physical properties of this char in controlling the flammability of plastics. Foamy char structure appears to be more fire resistant than brittle, thin char. Additives that increase the amount of char formation are known to be effective fire retardants. Fire-retardant additives for Polymeric Materials – I. Char  
15 Formation from Silica Gel-Potassium Carbonate, J W Gilman *et al*, Fire and Materials, Vol 21, 23-32 (1997) contains a review of char formation in various plastics and reports on the effect that silica gel and potassium carbonate additives have on polymer flammability.

When a plastic cable burns, the slumping or dripping of flaming polymer  
20 promotes the progression of the fire. The formation of a stable char layer after combustion of a section of the cable may protect the underlying part of the cable structure as it creates a barrier to further ignition. Furthermore, the formation of a char layer is believed to be responsible for the reduction in the rate of heat release sometimes observed in the Cone Calorimeter. Additives  
25 which have the effect of increasing the strength of the char formed when a plastic coated cable burns are therefore extremely valuable.

Nano-composites, made by mixing two or more phases such as particles, layers or fibres, where at least one of the phases is in the nanometre size range, are well known. Nano-clays and nano-composite clays are also  
30 known.

WO 97/30950 describes the manufacture of one type of such clays from smectite, in particular montmorillonite, and its use in thermoplastics. A family

WO 00/66657

PCT/GB00/01652

2

of such nano-clays is sold under the trade mark Cloisite. These are the reaction product of a smectite-type clay and a mixture of a quaternary ammonium compound and a chain transfer agent. The table below gives the organic modifiers that are used for the different grades of Cloisite. The clays

5 are said to be useful as additives or fillers for polymers. Each grade is adapted to use in a particular type of polymer. The resulting polymer composites can be moulded into articles by conventional shaping processes, such as injection moulding and extruding, so as to form for example components for the electrical and electronics industries. Among the

10 properties noted for the polymer composites are improved ignition resistance and non-drip characteristics.

	Organic Modifier (1)	Modifier Concentration	% Moisture	% Weight Loss on Ignition
Cloisite® 6A	2M2HT	140 meq/100g	2%	47%
Cloisite® 15A	2M2HT	125 meq/100g	2%	43%
Cloisite® 20A	2M2HT	95 meq/100g	2%	38%
Cloisite® 10A	2MBHT	125 meq/100g	2%	39%
Cloisite® 25A	2MHTL8	95 meq/100g	2%	34%
Cloisite® 30A	MT2EtOH	95 meq/100g	2%	32%
Cloisite® Na <sup>+</sup>	(natural sodium montmorillonite)		4%	7%

- 15 (1) 2M2HT: dimethyl dihydrogenated tallow ammonium  
 2MBHT: dimethyl benzyl hydrogenated tallow ammonium  
 2MHTL8: dimethyl hydrogenated tallow 2-ethylhexyl ammonium  
 MT2EtOH: methyl tallow bis-2hydroxy ethyl ammonium

Nanocomposites: Radiative Gasification and Vinyl Polymer Flammability,

WO 00/66657

PCT/GB00/01652

3

J W Gilman *et al* , International Wire and Cable Symposium Proceedings 1997, 761-774 contains a report that nylon-6 clay-nano-composites have improved char characteristics compared to pure nylon-6. There is also teaching to add clays to other polymers such as polystyrene and polypropylene-based polymers.

Fire Retardant Polyetherimide Nanocomposites, Jongdoo Lee *et al* , Mat. Res. Soc. Symp. Proc. Vol. 457, 1997 Materials Research Society, 513-518 reports the improved char formation brought about by the addition of nano-composites to plastics.

US Patent No 5,342,874 describes halogenated polymer formulations having flame retardant properties. They contain a synergistic flame retardant combination consisting of an aluminium or magnesium hydroxide and a tetravalent tin compound.

With the use of polymeric materials still on the increase, there is a need for improved fire retardant additives. The present invention is based on the finding that a combination of two or more previously known fire retardant additives gives a surprisingly strong effect.

According to this invention there is provided a polymer composition comprising a polymer and a synergistic flame retardant additive combination which comprises a nano-clay and a second filler, wherein, during combustion of the composition, a coherent char is formed.

A coherent char is a char which holds together and would not fall off an underside surface when that surface is positioned substantially horizontally.

It has been found that the presence of this flame retardant additive combination in polymers greatly increases the strength of the char that forms during combustion. As explained above, the formation of a strong char creates a barrier to ignition of the underlying material. The compositions of this invention are flame retardant at least in part because a strong char is formed.

The polymer composition of this invention may contain any nano-clay. However, Cloisite nano-clays (manufactured by Southern Clay Products, Inc) are particularly preferred.

WO 00/66657

PCT/GB00/01652

4

With regard to the second filler, this could be a known flame retardant such as aluminium trihydroxide (ATH) or an inert filler such as chalk or talc or glass powder. ATH is particularly preferred. An inert filler is one that does not have a flame retardant effect when used alone in a polymer. Other known inert fillers or flame retardant fillers could be used instead of or in addition to those listed above and still produce a synergistic effect. Examples of these include: magnesium carbonate, magnesium hydroxide (which could be added as either the refined compound or the ore Brucite), hydromagnesite, Huntite, boehmite, bauxite, borates (e.g., zinc borates) and molybdates (e.g., ammonium molybdates) particularly in combination with ATH and the nano-clay. It is to be understood that these fillers may be added to the nano-clay containing composition either individually or in combinations of two or more.

The particle size of the second filler is preferably less than  $10\mu\text{m}$ , more preferably less than  $5\mu\text{m}$ , most preferably less than  $2\mu\text{m}$ . The second filler may have a surface area which is greater than  $1\text{m}^2/\text{g}$ , preferably not greater than  $35\text{m}^2/\text{g}$ .

The proportion of the nano-clay component to the other filler component in the compositions of this invention is typically from 90% : 10% to 10% : 90% by weight. The proportion of nano-clay is preferably between 1 and 20% by weight of the total filler content. The total filler content (i.e. nano-clay plus the other filler) is from 20% to 80%, preferably from 40% to 70% by weight. The compositions may also include further constituents which are routinely present in conventional fire retardant products, such as stabilisers.

According to a further aspect of the present invention, there is provided a polymer composition comprising a polymer and a synergistic flame retardant additive combination which comprises a nano-clay and a second filler comprising at least one of aluminium trihydroxide, magnesium carbonate, magnesium hydroxide (or the ore Brucite), hydromagnesite, Huntite, boehmite and bauxite.

According to a further aspect of the present invention, there is provided a polymer composition comprising a polymer and a synergistic flame retardant additive combination which comprises a nano-clay and a second filler



WO 00/66657

PCT/GB00/01652

5

comprising at least one of chalk, talc and glass powder.

The fire retardant additive combinations which characterise this invention are suitable for inclusion in a wide range of plastics. Examples of suitable polymers include polyamides, nylons, polyesters, epoxy resins, ABS combinations, halogenated polymers such as polyvinyl chloride (PVC), polyethylenes, polypropylenes, polyurethanes, polystyrenes, polychloroprene, phenolics, silicones, and silicone rubbers and copolymers and combinations of polymers. The particularly preferred use of the compositions of this invention is in cables for electrical or optical transmission. Flexible PVC has been a material of choice for cable sheathing for many years. The compositions may, for example, also be used to coat other moulded or extruded materials. The coating may be, for example, a sheath, jacket or insulation.

According to a further aspect of the present invention, there is provided the use of the polymer composition as a char promoter.

There is also provided a char promoting composition comprising a polymer and a synergistic flame retardant additive combination which comprises a nano-clay and a second filler.

According to a further aspect of the present invention, there is provided a method of improving the char promoting properties of a polymer composition, which method comprises the steps of combining a polymer and a synergistic flame retardant additive combination which comprises a nano-clay and a second filler.

The compositions of this invention result from the finding that adding a nano-clay, such as Cloisite, and a second filler, such as ATH, to plastics surprisingly and significantly increases the strength of the char that forms during combustion. The reason for this synergistic effect is not known. It is possible that the ATH or other filler aids mixing of the clay and the polymer, or perhaps there is some chemical or physical effect that occurs during burning, or perhaps the fillers mechanically reinforce the char, or the filler acts as a support for the nanoclay, but the applicant is not restricted to these explanations.

WO 00/66657

PCT/GB00/01652

6

The synergistic effect is illustrated in the following example. Of the three sample formulations tested (namely: one with ATH alone, one with nano-clay alone and one with both of these additives), only the sample of the composition according to this invention was able to pass the char test.

5 The invention will now be described, by way of illustration, with reference to the following examples and in which:

Figures 1 and 2 show silica mapping of Example 1; and

Figures 3 to 6 show char test results for Example 2.

10 **EXAMPLE 1**

**Formulations:**

The following three formulations were prepared according to the procedure described below.

EVA45 is based on 65% ATH, EVA46 on 5% nano-clay, and EVA47 on  
15 60% ATH plus 5% nano-clay. All percentages are by weight.

Ingredients	EVA045-99	EVA046-99	EVA047-99
Escorene Ultra 00119 (EVA)	100	100	100
SF7E (ATH)	185	-	170
Cloisite 30A	-	5.3	15
Aminosilane 1100 (coating for ATH)	1.85	-	1.7
Irganox 10-10 (stabiliser)	0.5	0.5	0.5

The figures quoted in the table are "phr", i.e. parts by weight per hundred parts of polymer. In the table, the compositions are given in parts by weight.

20



WO 00/66657

PCT/GB00/01652

7

**Procedure:**Mixing

EVA45 and EVA47 were produced on a Banbury BR1600 (batch mixer) according to the following procedure. The ingredients were added in the following order:

1<sup>st</sup> addition: Escorene + half of the filler.

2<sup>nd</sup> addition: half of the filler + silane + stabiliser (+ nano-clay for EVA47).

They were mixed until the ingredients were adequately dispersed.

A different recipe was used to mix EVA46. Namely, the three ingredients were placed together and mixed until an adequate dispersion was obtained.

The batches from the Banbury mixer were then calendered on the two roll mill at approximately 95°C to form a hide. 3mm thick by 15cm square plaques were compression moulded at 150°C from the hide and 5cm square samples were cut out from the plaques and tested according to the char test procedure (described below).

A plaque of each of the compounds EVA46 and EVA47 was frozen using liquid nitrogen, and broken into 2 pieces. The fractured surface was then analysed using EDS mapping. Aluminium and silicon enriched areas were mapped to determine whether the nano-clay was well dispersed.

Char Test Procedure

The samples to be subjected to the test are in the form of panels measuring 5 cm<sup>2</sup> and 3 mm in thickness. They are held vertically by means of a U-shaped frame. A load cell incorporated in the frame is connected to a chart recorder.

Once the apparatus has been set up, a fish tail flame is applied to the bottom edge of the panel. The flame impinges along the whole length of the bottom edge of the panel in the frame. It is allowed to burn and the mass of the panel diminishes. The chart recorder plots mass loss against time.

The test continues until either there is no more mass loss or there is a sudden mass loss. If the sample under test has formed a strong char which is staying in place (this is an example of a coherent char), the mass loss curve

WO 00/66657

PCT/GB00/01652

8

will by asymptotic to time. At the end of the test, the sample either falls out of the frame or stays in the frame. In the latter case, the sample panel can be tapped and if it still remains in the frame then a strong char has been formed during its combustion.

5       The tapping test was carried out on samples subjected to the char test that did not show substantial sudden weight loss during the test. Although subjective, it provides a good indication of how coherent the char is. The test is performed by tapping the char with a metal spatula. Char that disintegrates or falls off easily is rated 1 or 2. Char requiring a harder tap to cause it to  
10       break off was rated 3 or 4 and deemed to have passed the test. The most coherent char that survived tapping was rated 5.

#### Results:

Both EVA45 and EVA46 failed the test and fell from the sample holder in  
15       about one minute. EVA47 stayed on the sample holder for the whole duration of the test. It gave a total mass loss of 49% and a strong char.

The nano-clay is mainly constituted of silica. Therefore, silica was mapped on both EVA46 and EVA47. The results are shown in Figures 1 and 2 (the silicon clusters, representing clay, appear as white dots). EVA46  
20       showed large agglomerates of clay (up to 100  $\mu\text{m}$ ). Clay particles up to 10  $\mu\text{m}$  were still visible in EVA47.

Neither ATH nor nano-clay gave a strong enough char when used on their own at the conventionally recommended addition levels. The results demonstrate that the only way to obtain a strong char is to use both together.

25       Very coarse agglomerates of clay were observed in EVA46. Agglomerates were still visible in EVA47 but were much smaller. The ATH seems to have helped the dispersion or mixing of the clay. This could explain the results obtained during the char test. However, it is not clear if this is the only explanation for the strength of the char.

30

WO 00/66657

PCT/GB00/01652

9

**EXAMPLE 2****Formulations:**

The following formulations were prepared according to the procedure described below.

- 5 EVA119 and EVA121 are based on 65% filler, EVA120 and EVA122 60% filler plus 5% nano-clay. All percentages are by weight.

Ingredients	EVA119	EVA120	EVA121	EVA122
Escorene Ultra 00119	100	100	100	100
Polcarb	185	170	-	-
Ultracarb 5	-	-	185	170
Cloisite 30A	-	15	-	15
Irganox 10-10	0.5	0.5	0.5	0.5

In the table, the compositions are given in parts by weight.

- 10 Polcarb is a 1-micron  $\text{CaCO}_3$  with a surface area of  $7\text{m}^2/\text{g}$  sold by ECC.  
 Ultracarb 5 is a mix of huntite ( $\text{Mg}_3\text{Ca}(\text{CO}_3)_4$ ) and hydromagnesite ( $\text{Mg}_4(\text{CO}_3)_3(\text{OH})_2\cdot 3\text{H}_2\text{O}$ ), with a  $d_{50}$  lower than 1 micron and a surface area of  $15\text{m}^2/\text{g}$ , that is sold by Microfine Minerals.  
 Cloisite 30A is a nanoclay sold by South Clay Products and which has  
 15 been treated using a surface modifier specially chosen for EVA polymers.

**Procedure:**

EVA119, 120, 121 and 122 were produced on the Banbury BR1600 according to the following procedure:

- 20 1<sup>st</sup> addition: Escorene + half of the filler (+ nanoclay for EVA120 and EVA122) then mix.

2<sup>nd</sup> addition: half of the filler + stabiliser then mix and afterwards cool for 2 minutes at 10RPM.

5cm square samples were prepared and tested in the char test as

WO 00/66657

PCT/GB00/01652

10

described in Example 1.

Results (see Figure 3 to 6):

Char test/LOI

- 5 Both EVA119 and EVA121 failed the char test in one to two minutes. EVA120 and EVA122 passed the test. They gave a char strength respectively 3 and 4.

	EVA119	EVA120	EVA121	EVA122
Max Total Mass Loss by Char Test	-	40.5%	-	62%

- 10 It can be seen that both fillers alone failed the char test, but passed in the presence of the nanoclay. The filler alone does not give any char. The clay alone is dragged down from the sample support by the melting polymer before acting as a char promoter.

WO 00/66657

PCT/GB00/01652

11

**CLAIMS**

1. A polymer composition comprising a polymer and a synergistic flame retardant additive combination which comprises a nano-clay and a second filler, wherein, during combustion of the composition, a coherent char is formed.
2. A polymer composition as claimed in claim 1, wherein the nano-clay is Cloisite.
3. A polymer composition as claimed in claim 1 or claim 2, wherein the second filler is a known flame retardant filler, an inert filler or a combination thereof.
4. A polymer composition as claimed in any one of claims 1 to 3, wherein the second filler comprises at least one of aluminium trihydroxide, magnesium carbonate, magnesium hydroxide (or the ore Brucite), hydromagnesite, Huntite, boehmite and bauxite.
5. A polymer composition as claimed in any one of claims 1 to 3, wherein the second filler comprises at least one of chalk, talc and glass powder.
6. A polymer composition as claimed in any one of claims 1 to 5, wherein the proportion of the nano-clay to the second filler is from 90% : 10% to 10% : 90% by weight.
7. A polymer composition as claimed in any one of the preceding claims, wherein the total filler content is from 20% to 80% by weight.
8. A polymer composition as claimed in any one of the preceding claims, wherein the polymer is PVC.

WO 00/66657

PCT/GB00/01652

12

9. A polymer composition comprising a polymer and a synergistic flame retardant additive combination which comprises a nano-clay and a second filler comprising at least one of aluminium trihydroxide, magnesium carbonate, magnesium hydroxide (or the ore Brucite), hydromagnesite, Huntite, boehmite and bauxite.
10. A polymer composition comprising a polymer and a synergistic flame retardant additive combination which comprises a nano-clay and a second filler comprising at least one of chalk, talc and glass powder.
11. A cable or wire coating formed from a polymer composition according to any one of claims 1 to 10.
12. A moulded or extruded material coated with a polymer composition according to any one of claims 1 to 10.
13. Use of a polymer composition according to any one of claims 1 to 10 as a char promoter.
14. A char promoting composition comprising a polymer and a synergistic flame retardant additive combination which comprises a nano-clay and a second filler.
15. A method of improving the char promoting properties of a polymer composition, which method comprises the steps of combining a polymer and a synergistic flame retardant additive combination which comprises a nano-clay and a second filler.

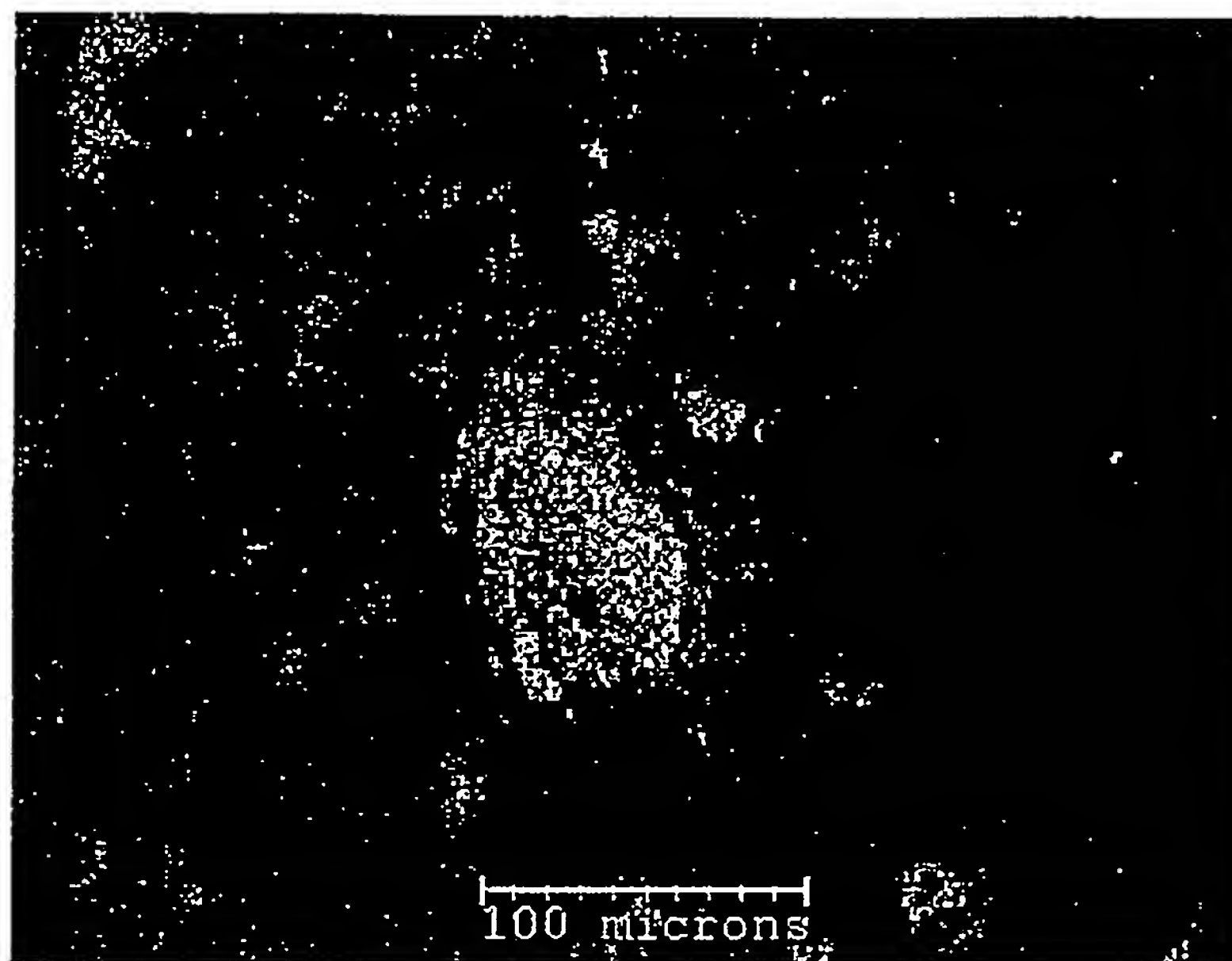


WO 00/66657

PCT/GB00/01652

1 / 3

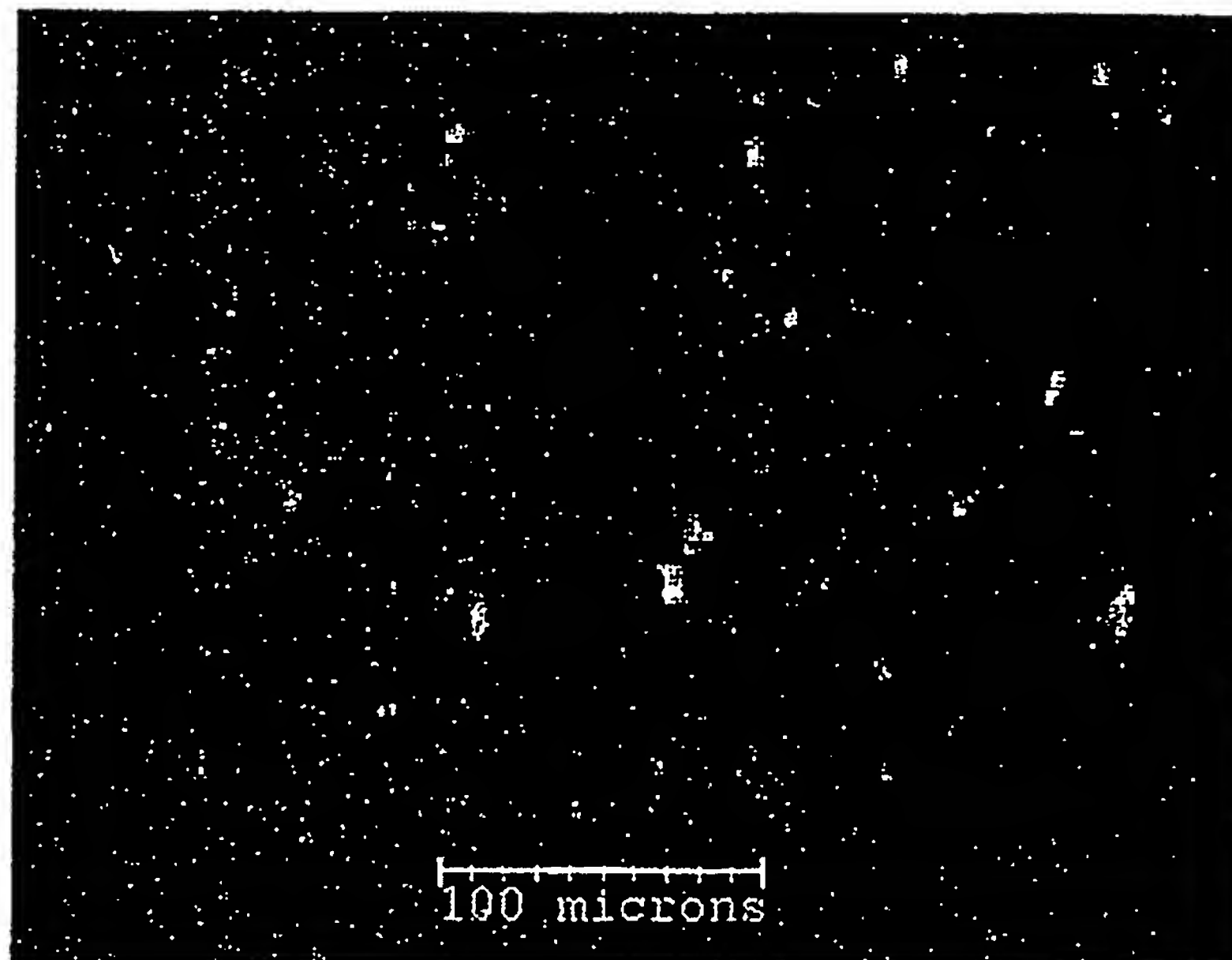
EVA 46: SILICA MAPPING



Si

FIG. 1

EVA 47: SILICA MAPPING



Si

FIG. 2

WO 00/66657

PCT/GB00/01652

2 / 3

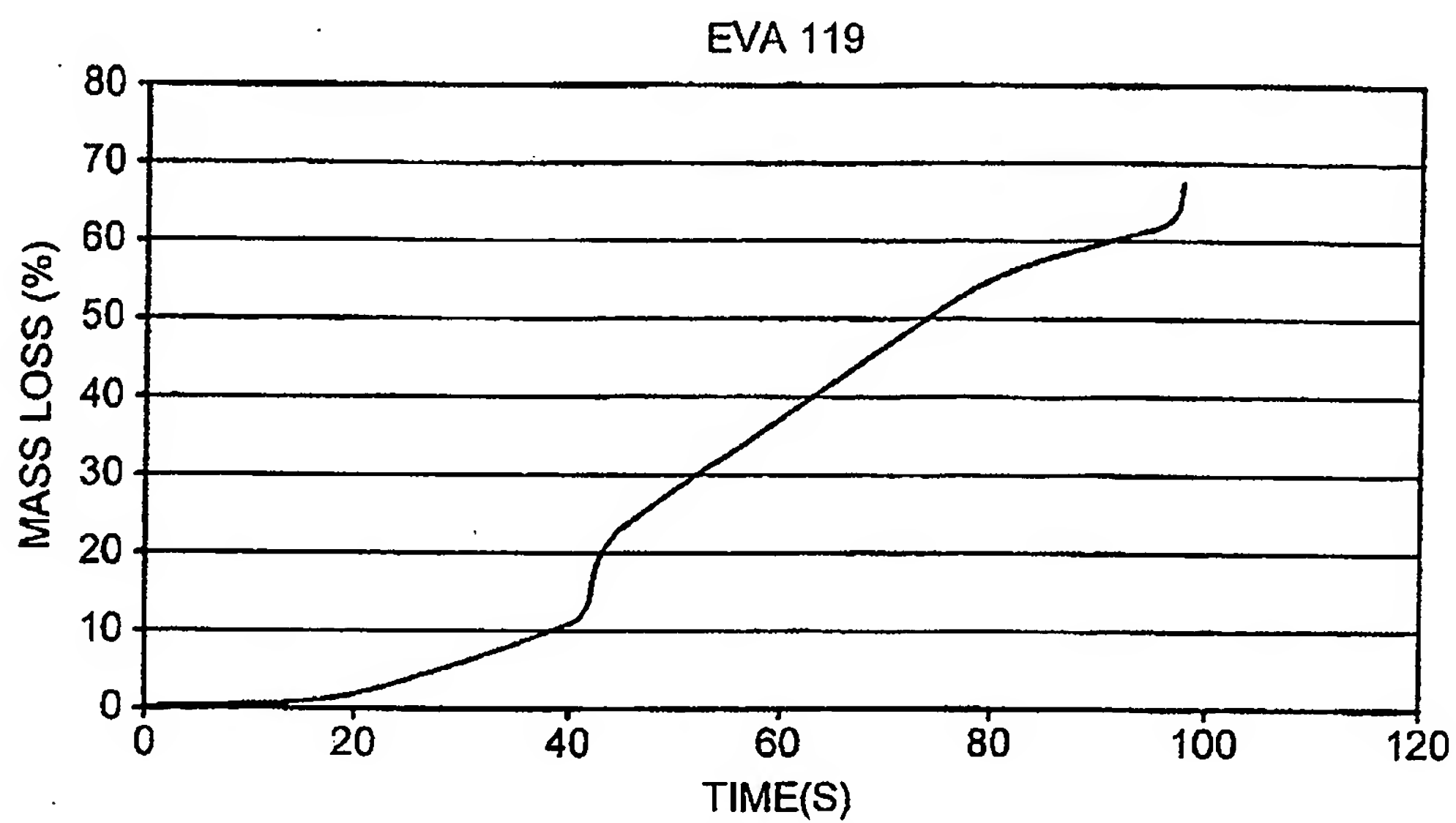


FIG. 3

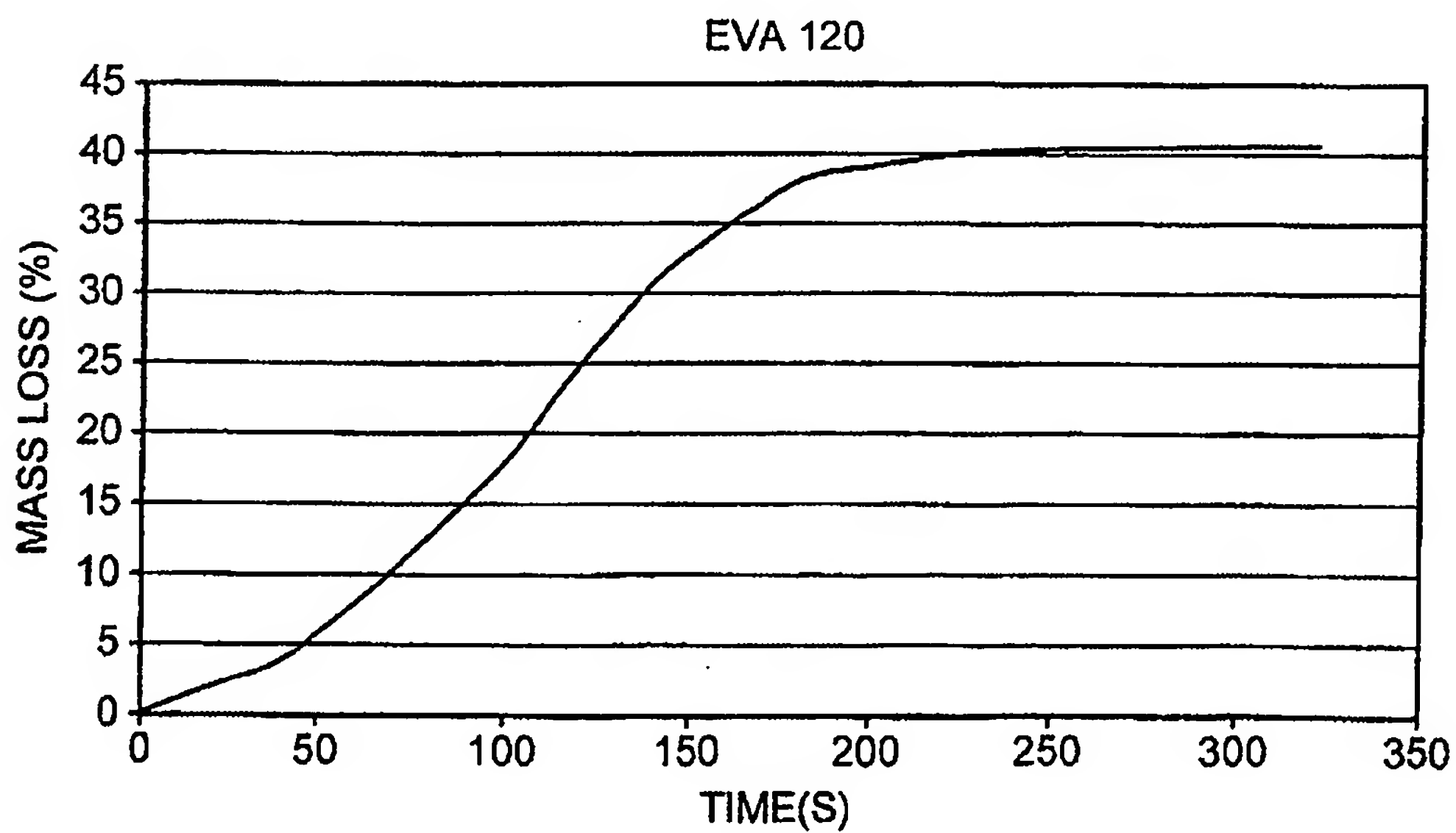


FIG. 4

SUBSTITUTE SHEET (RULE 26)

WO 00/66657

PCT/GB00/01652

3 / 3

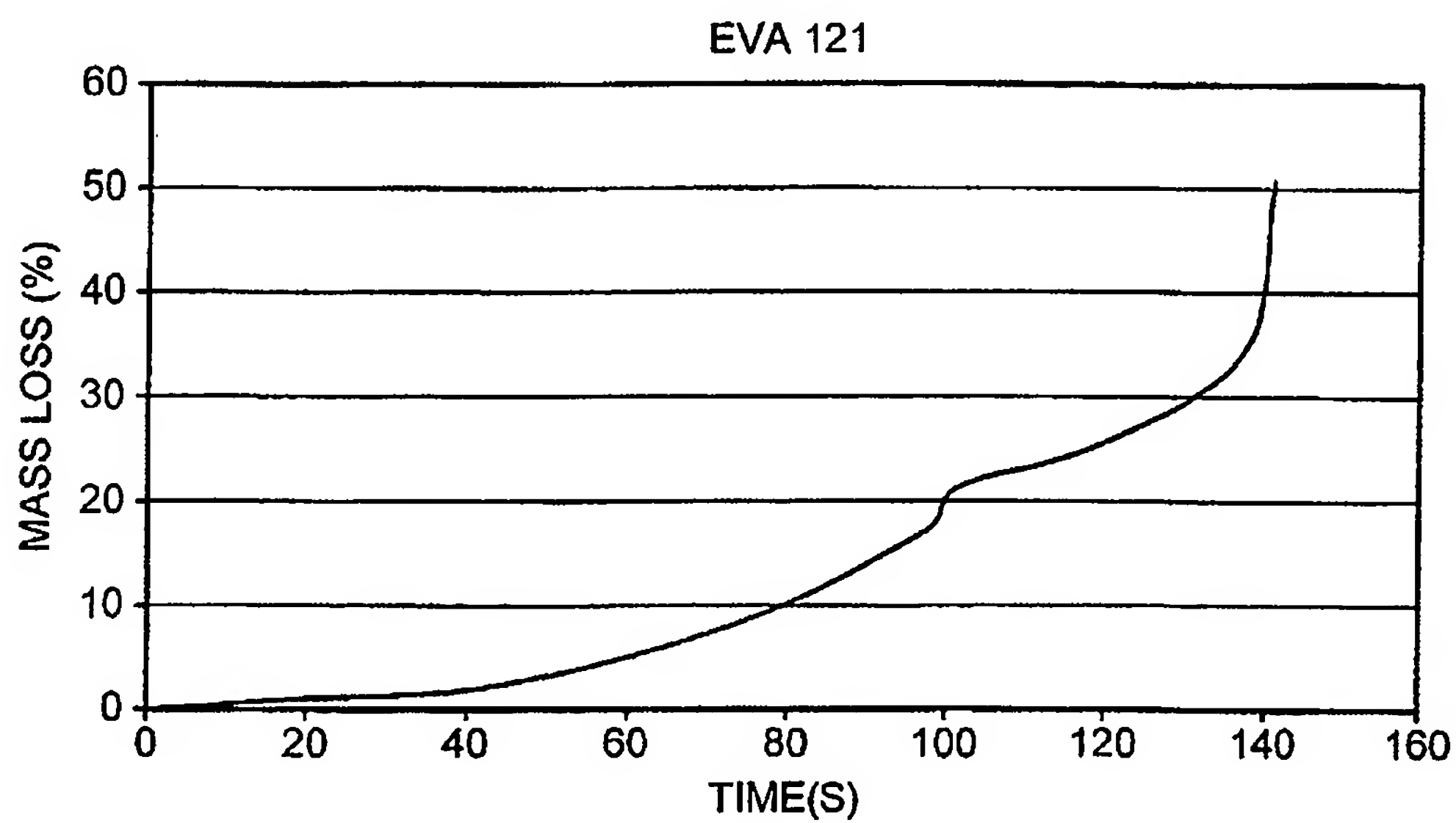


FIG. 5

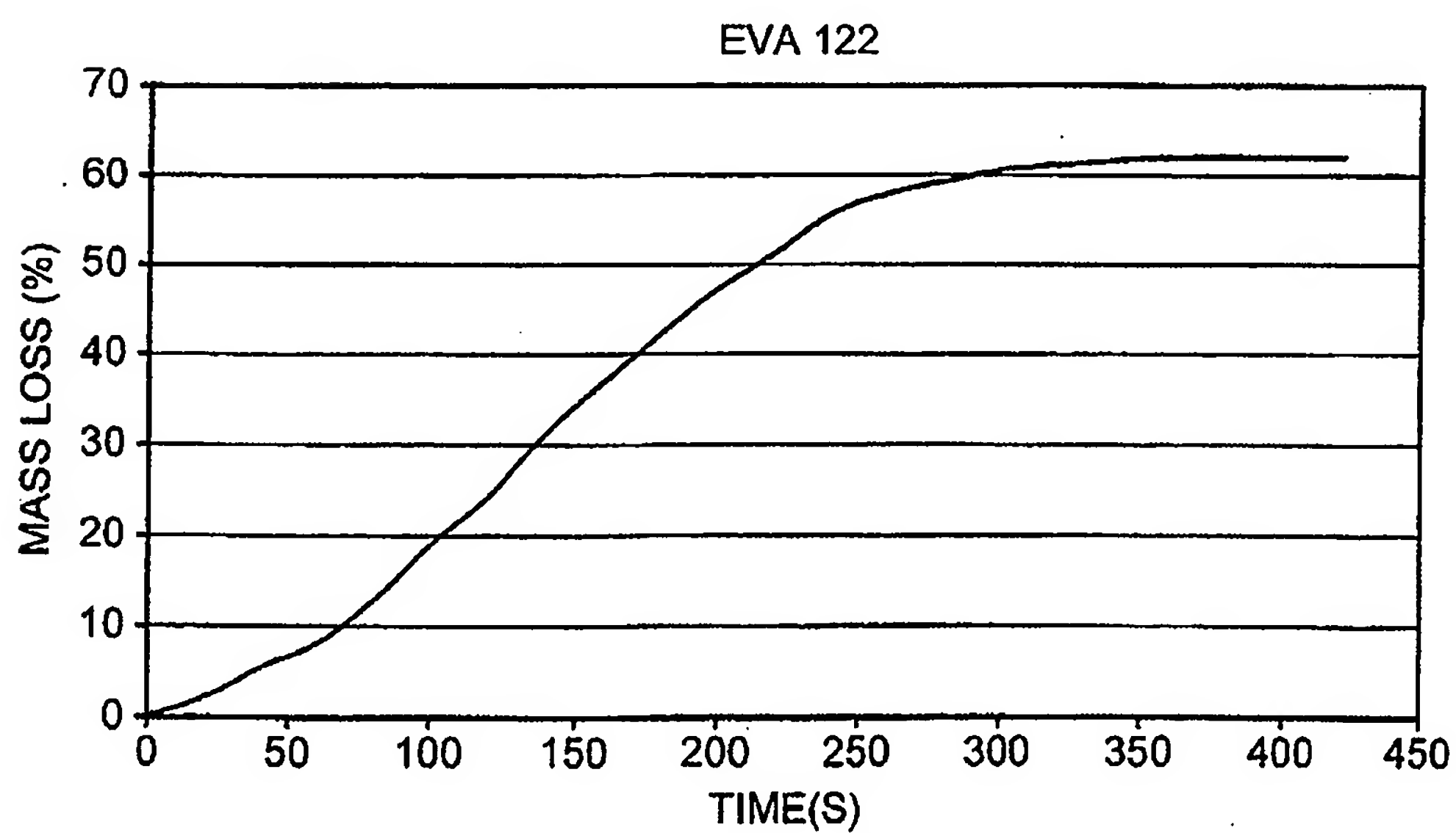


FIG. 6

SUBSTITUTE SHEET (RULE 26)

## INTERNATIONAL SEARCH REPORT

		Inter national Application No PCT/GB 00/01652
A. CLASSIFICATION OF SUBJECT MATTER IPC 7 C08K3/34 C08K9/04		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC 7 C08K		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 459 472 A (TOYODA CHUO KENKYUSHO KK) 4 December 1991 (1991-12-04) claims 1-11	1-8, 11
A	WO 97 30950 A (DOW CHEMICAL CO ; SOUTHERN CLAY PROD INC (US)) 28 August 1997 (1997-08-28) cited in the application page 10, paragraph 3 -page 11, paragraph 3 example 1 claim 1	1-15
<input type="checkbox"/> Further documents are listed in the continuation of box C. <input checked="" type="checkbox"/> Patent family members are listed in annex.		
<p>* Special categories of cited documents :</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&amp;" document member of the same patent family</p>		
Date of the actual completion of the international search 21 July 2000		Date of mailing of the international search report 02/08/2000
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3018		Authorized officer Siemens, T

## INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 00/01652

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0459472 A	04-12-1991	JP 2872756 B	24-03-1999
		JP 4033955 A	05-02-1992
		DE 69111696 D	07-09-1995
		DE 69111696 T	25-01-1996
		US 5164460 A	17-11-1992
WO 9730950 A	28-08-1997	AU 1966397 A	10-09-1997
		US 5780376 A	14-07-1998

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

☒ **BLACK BORDERS**

☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**

☐ **FADED TEXT OR DRAWING**

☐ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**

☐ **SKEWED/SLANTED IMAGES**

☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**

☐ **GRAY SCALE DOCUMENTS**

☐ **LINES OR MARKS ON ORIGINAL DOCUMENT**

☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**

☐ **OTHER:** \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**